

# Invisible writing (practices) in the engineering curriculum?

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## CONTEXT

It has become almost a cliché that engineers, (and by association engineering students) don't, won't, can't write. In order to redress this gap, there have been many excellent (and some successful) attempts in recent decades to develop the writing of engineering students, both in Australian universities and elsewhere. Yet the problem remains unresolved, with employer groups, Engineers Australia and engineering faculties recognising that engineering students are still graduating with less than adequate written or spoken communication skills. This study focuses on potential inhibitors of the development of writing practices in the engineering curriculum.

## PURPOSE OR GOAL

This study investigates factors that inhibit writing in the engineering curriculum at the level of engineering academics, as it is often they who determine what, how or if writing practices are developed in the engineering subjects they teach. The purpose of this research is to identify and subsequently make visible any gaps and contradictions in writing practices in the engineering curriculum, so that engineering academics and curriculum designers can then see how they may address these gaps.

## APPROACH

The study uses discourse of writing as a social practice to focus on interactions between individuals, writing practices and the engineering curriculum, by interviewing engineering academics and by examining the writing practices of engineering academics and students. These data are currently being analysed to see what tensions and contradictions emerge.

## ACTUAL OR ANTICIPATED OUTCOMES

Preliminary results have exposed tensions between how engineers see their students' writing practices and how they model their own practices for their students. There are also divergent views about writing as a practice or as a product.

## CONCLUSIONS/RECOMMENDATIONS/SUMMARY

From the preliminary results, conclusions can be drawn about whether engineering academics can see writing practices as part of engineering practice, and the extent to which their perspectives are influenced by prior experience. The knowledge of varying levels of awareness could then be used to assist in ensuring that writing practices have a more central position in the engineering curriculum than is currently the case. This in turn should develop engineering graduates who are better prepared for the writing practices of engineering.

## KEYWORDS

Engineering curriculum; writing practices; discourse of writing as a social practice

## Background

Writing practices are intrinsic to engineering practice, are identified as a key competency (under the umbrella term “communication”) by Engineers Australia and by Australian engineering faculties and universities and yet are often invisible in the engineering curriculum. Despite a wide range of programs, projects, online and physical resources to support the development of writing practices in the curriculum, there is evidence to show that these initiatives are not sustained in the medium or long term. There is thus a strong implication that writing practices are not seen as intrinsic to the engineering curriculum. At the same time, recent national and international research has identified a number of gaps in the development of communication in engineering graduates (King, 2008; RAE, 2006; Sheppard et al. 2009). Several recent studies point out the extensive demands made on graduate engineers in terms of their writing, as compared to what is perceived both by engineering academics and by students: Trevelyan (2010) reports that practising engineers spend 60% of their time interacting with other people, yet the commonly held perception by engineering academics is that of the engineer as the solitary problem-solver (Radcliffe 2006; Trevelyan 2010). Similar observations are made by Male and Chapman (2009; 2011) in their extensive study of engineering graduate competencies and the gaps therein. The available evidence indicates that these gaps occur in part as a result of a predominance of engineering curricula in universities which emphasise knowledge acquisition, and the prevailing assessment tasks that measure the learning of atomised pieces of knowledge by means of short answer quizzes and examinations. The use of such assessments tends to preclude the development of writing practices, in addition to reinforcing perceptions of engineers as technical rationalists who do not need to write.

This lack of visibility of writing practices in the curriculum, with the associated disengagement of the development of writing in the discipline by faculty staff, is evident in engineering faculties throughout Australia and overseas, despite ongoing concerns about the quality of writing of engineers (Appleby et al. 2012; King, 2008; Male, Bush & Chapman, 2011; McKenna, 1997; Mort & Drury, 2012; Trevelyan, 2009; 2010). Why is such an important aspect of being an engineer and of doing engineering so invisible in the curriculum (and in academic practice)? The importance of written and spoken communication is clearly demonstrated by its inclusion in engineering faculty graduate attributes and in Engineers Australia key elements of competency (2011). It is also noted in a number of reports and studies (King, 2008; Male, Bush & Chapman, 2011; Trevelyan 2009, 2010). Yet the responsibility for the development of this attribute and the visibility of writing in the engineering curriculum are much less obvious.

In order to redress this situation, there have been many excellent (and some successful) attempts in recent decades to develop the writing of engineering students, both in Australian universities and elsewhere: (see, for example, Carter, Ferzli, & Wiebe, 2007; Herrington, 1985; Hilgers, Hussey, & Stitt-Bergh, 1999; Mort & Drury, 2012; Wheeler & McDonald, 2000). Arguably one of the best examples is the WRiSE (Writing Reports in Science and Engineering) site (Mort & Drury 2012). The authors outline the development of an online writing resource for students in engineering and science in Australian universities, including evaluations by students and staff. Student responses to the site showed it was regarded as highly effective; faculty staff commented that it was a very useful resource, yet the authors indicate that faculty staff do not promote and encourage students to use the site unless prompted by learning advisers. This suggests that the majority of faculty staff do not appear to share the responsibility for developing student writing in their disciplines, even when a resource such as an online writing site is readily available.

Given the acknowledgement of the importance of writing practices in engineering, and the considerable number of initiatives that have been undertaken to promote them only to wither on the vine, it appears that something or things inhibit writing in the engineering curriculum. The question is: what? As universities are complex organisations, or super-complex as

Barnett (2000) would say, it is likely that there are a number of interacting factors that inhibit writing practices, at the level of the institution, the faculty, the curriculum and individual academic staff.

This paper presents findings from the first stage of a major project that is investigating what inhibits writing practices in the engineering curriculum at the level of engineering academics. This focus has been taken as it is predominantly the subject coordinators in engineering faculties who determine what, how or if writing practices are developed within the engineering subjects they teach. The importance of this project is that it seeks to make visible the perceptions of writing practices in the engineering curriculum. It can also make visible the gaps in the development of writing practices, in order to develop sustainable strategies that can be embedded into the curriculum to address these gaps.

## Approach

When engineering curricula are scrutinised for evidence of the development of writing practices, there appear to be substantial gaps; there may be an engineering communication or a design-build subject in first year that emphasises teamwork and report writing, but beyond that the opportunities for students to develop writing practices are piecemeal. This is particularly obvious in the second and third year 'engineering science' subjects, such as thermodynamics, fluid mechanics and solid mechanics (Lucena, 2003, p.421). Are the practices invisible, or do they not exist at all? Are they invisible to the academics teaching the subjects? Are the learning opportunities provided by these writing practices also invisible? Are they invisible to all engineering academics? If they are invisible to the academics, how can they be made visible to engineering students? What are the potential impacts on engineering students of 'invisible writing practices', or gaps in writing practices? Attempting to answer these questions then leads to considerations about the most appropriate theoretical perspectives and methodology to investigate what might lie behind this lack of visibility. The challenge is to find an approach that can investigate absences, invisibilities, gaps in practices or in perceptions.

The study uses activity theory and the discourse of writing as a social practice to focus on interactions between individuals, writing practices and the engineering curriculum, by interviewing engineering academics and by examining the writing practices of engineering academics and students. Activity theory is a theoretical framework that takes a multidisciplinary research approach to analyse human interactions in a socio-cultural historical context (Vygotsky 1978; Engestrom 2001; Behrend 2014). The discourse of writing as a social practice is concerned with the beliefs about writing and learning to write; it sees writing as socio-culturally constructed, as practices that are learned and developed in different contexts, and where writers respond to different audiences, purposes and circumstances (Ivanic 2004). This perspective will provide ways of talking about the beliefs about the writing that engineers do, and may allow engineers to make those beliefs more visible or more explicit. As both activity theory and the discourse of writing as a social practice are situated in sociocultural theory, they provide complementary lenses with which to view the research questions and the data. Due to reasons of space, this paper will focus on the discourse of writing as a social practice as the theoretical lens with which to view the current findings. Activity theory will be used in a later phase of the research.

In order to explore the "constellations of beliefs about writing, about learning to write..." (Ivanic, 2004, p.224) of engineering academics, I have focused on investigating what they do, say, and write about writing practices in the engineering curriculum. This involves recruiting suitable participants: engineering academics who coordinate an engineering subject in undergraduate or postgraduate degree programs in Australian universities. Subject coordinators have been selected as they have a certain amount of control over what and how students are taught, and what and how students are assessed. The participants are asked to provide relevant documents such as subject outlines, support documents and samples of student assignments if available. I also search for published writing by the participants (available in the public domain). The documents are analysed and the participants are then

interviewed using semi-structured questions to investigate how they view their students' writing practices, their own writing practices as engineers, and the writing practices of the engineering curriculum.

The discourse of writing as a social practice has developed a framework of different approaches to the teaching and development of writing practices. These approaches include a decontextualised skills-based approach, where the skills of writing are separate from the content being written about. Then there is the social practices discourse of writing perspective, which shares the view of the learning theories underpinning communities of practice (Brown, Collins & Duguid 1989; Lave & Wenger 1991), where people learn implicitly by participating (initially as apprentices or novices) in the activities of the workplace. The (literacy) learning takes place through purposeful participation, and as it is implicit it does not require direct instruction. There is also a socio-political discourse that sees writing as socio-politically constructed and open to contestation (Ivanic, 2004, p.225). This framework is a useful tool to analyse the participants' beliefs about writing practices, whether or not these beliefs are explicitly articulated. The interview responses and documents are analysed initially using Concordance to identify frequency of words; these are then grouped to identify emergent themes. A linguistic analysis of the interviews is also being conducted to examine the agency and roles of the participants in the activity system; this analysis will be presented in a later paper.

## Results and Discussion

Participants have been recruited from several Australian universities, including members of the Go8 and ATN. Thus far, all the engineering academics who have agreed to participate in the study have claimed either in the interview or in their subject outline or both that they develop students' writing practices in the engineering curriculum. It is noteworthy that no academic has chosen to participate in the study who does not claim to develop students' writing practices. At this stage of the study I am seeking more actively to recruit participants who do not seek to develop students' writing practices, but as involvement in the study is voluntary I can only rely on the goodwill and willingness to cooperate of the academics who are contacted. If engineering academics who do not develop students' writing practices choose not to participate, it means that their perspective will not be included in the final study. This then becomes another aspect of the narrative of the invisibility of writing practices in the engineering curriculum.

The subjects coordinated by the participants are mainly technical; the engineering disciplines include civil, electrical and mining. One subject is within the strand of engineering practice, where students do pre- and post-internship subjects in order respectively to prepare for and reflect on their internship experiences. The themes which have emerged from the analysis include:

- **What I say is not always what I do**
- **Curriculum? What curriculum?**
- **Writing by osmosis (but that's not how I learned)**

**What I say is not always what I do:** All the participants interviewed so far indicate that they see writing practices as an important part of engineering practice. They all have writing tasks as assessable items in addition to other assessment items such as presentations, quizzes, mid and final semester exams; see table 1 for a summary of the various writing tasks and weightings. At the same time, there is a disparity between what is claimed in the learning outcomes, what is specifically taught or developed, and what is assessed.

**Table 1: summary of writing tasks and practices**

Participant	Writing tasks/practices	Writing as subject learning outcome?	Part of broader program?
1	3 Reports worth 60% of total assessment	Yes	No
2	2 reports worth 40% of total assessment	No	No
3	Reflective report worth 55% of total assessment	Yes	To an extent
4	Scaffolded writing tasks; 4 reports worth 70% of total assessment	Yes	Yes
5	Group project worth 20% of total assessment	No	No

This disparity is exemplified in Participant 1's responses and subject outline. In reply to the question "what do you see to be the purposes of writing in your subject?" Participant 1 makes the comment that "At a deeper level it's an opportunity for students to learn how to write engineering reports". In Participant 1's subject, students are required to write three reports which are sequential in terms of complexity of reporting tasks. His expectations of the students' work are that they write in an appropriate report format and justify their calculations. However, there is no indication in the subject outline or in handouts for assignments one and two that the students are expected to write a report. The word *report* does not occur until assignment three: "Any assumptions needed to develop the [design aspects] need to be discussed in the assignment report" (Assignment 3 description, p.1). Students are not provided with a model or an exemplar of what is required in the reports, nor are they given information about how the reports are to be structured:

*I tell them what I want in terms of that but I don't really give them an example of one. What I would suggest is it's really a hurdle that - they've got to get over the hurdle without a lot of actual marks being attributed to that component* (Participant 1).

In terms of conceptions about writing practices, this indicates a quite complex and possibly conflicting set of beliefs. There is not only a gap between rhetoric and practice, but also a gap in regard to how writing practices are learned or acquired. On the one hand the participant states that his subject provides an opportunity for students to learn how to write engineering reports, but on the other hand there is no direct instruction or modelling of writing practices to facilitate the learning. It is up to the individual student to seek feedback, in effect making the assessments summative rather than formative. Is there an assumption that students know 'how to write', and therefore don't need to be shown the specific language and textual features that are integral to an 'engineering report'? (A discussion of the range of types of engineering reports will be included in a later stage of the project). If this is the case, Participant 1 could have a skills-based approach to writing, where writing 'skills' are somehow separate from the content that is being conveyed through the writing (Ivanic, 2004), and certainly suggests that writing practices are invisible, at least in this subject. This is borne out when Participant 1 makes the comment that the report structure is a 'hurdle' that the students have to overcome "*without a lot of actual marks being attributed to that component*" (Participant 1).

In contrast to the previous subject coordinator, Participant 3 sees the purpose of writing in his subject as:

*Demonstrating [students'] development. This is it. You have to show me that your 24 weeks of experiment actually resulted in you moving from A to B, as part of your course, in that I can read it and I can relate to your experience* (Participant 3).

As outlined in table 1, the writing task for this subject is an assessable reflective report, where the students describe and reflect on their experiences as interns. The learning guide that accompanies the subject outline has exhaustive information about the structure, the

layout and the type of writing that the report is expected to contain. Opportunities are provided for peer and tutor feedback on the reflective report that the students are required to write, but there is no provision for scaffolding the report. Scaffolding involves structuring the learning activities so that students can develop the skills required and eventually become autonomous learners. Scaffolding can include guided (report) writing, the provision of exemplars or models, and making explicit the structures and purposes of various stages of a text type. There is also no opportunity for in-class writing practice, although this has more to do with the structure of the subject as it is delivered in block mode: *"I would like to have an extra tutorial, just to deal with writing, and I haven't had yet the opportunity to add the extra tutorial"* (Participant 3). From this, it appears that Participant 3 has a belief of writing to demonstrate learning.

An example of good practice is to be found in Participant 4's subject. In terms of developing students' writing practices in an engineering curriculum, Participant 4's initiatives are structured, scaffolded, contextualised and explicit. The participant is an academic in a school of mining engineering which is a member of Mining Education Australia (MEA), four universities that deliver a common curriculum for years 3 and 4 of the Bachelor degree in Mining Engineering. This membership, together with a relatively small cohort that remains together for the four years of the degree program, seems to create a sense of continuity and a developmental approach towards many aspects of students' learning, including those of writing practices. Participant 4 has co-authored a report writing guide for mining engineering students used by all the member universities of MEA. In addition to participant 4's subject feeding into the common curriculum of MEA, he is the only participant so far to have worked closely (or at all?) with a language and learning (ALL) adviser, who is the co-author of the report writing guide and who also worked on developing the WRiSE site.

*...The field trip report has evolved as well in the last two or three years in terms of - and this came from a suggestion from [learning adviser]. We get the students to do a preliminary report...The idea of the preliminary report is for the students to have two turns at writing the report. The first one, preliminary, it's a draft report in terms of them putting the report together* (participant 4)

As can be seen from this comment, the students are required to submit a preliminary report which provides both the opportunity for scaffolding the report writing task and for feedback/feed forward for the final report. These targeted strategies to develop students' writing practices in the context of their engineering discipline are in contrast to what happens in other participants' subjects, where the strategies to develop students' writing practices are less structured, less visible, and more implicit. Participant 4 can be seen to have a social practices discourse of writing perspective, but one which is also informed by his interactions with the ALL adviser at his institution.

**Curriculum? What curriculum?** This theme underlines the lack of visibility of the development of writing practices. When the participants describe specific tasks that develop students' writing practices, most of these initiatives have come from the subject coordinators themselves. There are few comments about the curriculum playing a part in developing students' writing practices; in fact the majority of the interviewees make few references to how their subject fits into the engineering curriculum unless they are specifically asked. Participant 2 seeks to give students opportunities to develop their writing practices through collaborative activities in tutorials and interactive lectures; the participant does not refer to this being part of a continuum of development, and instead notes that many colleagues have the view that: *"Because I think they see themselves as the subject co-ordinator for that particular subject so because development of writing skills may not be a specifically listed learning outcome of their subject they'll say well that's not my job to do that"* (Participant 2). There is little sense of development happening beyond what the individual academic is doing; very few comments relate to what the students will do after completing this subject, unless the academic also coordinates a later year subject. This is also matched by an absence of an expressed sense of being part of the faculty. When asked the question: "do your views about writing practices and what Engineering students need to do in terms of their writing practices - do you think your views reflect the faculty view?", the most common

response was in the negative: *"if you look for a faculty view in published documents there is probably an alignment there but the faculty view as practised I would say is a bit different"* (participant 2). In some cases, participants make the point that they are unable to comment on what the faculty view is: *"I can't talk about the faculty at all. I can only talk at the school level"* (Participant 4); *"Seriously, I don't know. This is another thing"* (Participant 3);

*"...No. I think it just comes down to individuals. They have their different - they place different levels of emphasis. So that comes back to I think reflecting on the involvement of people. So some don't see so much issues about report writing. All they see, well if someone else is looking after that, I don't have to pay so much attention to it"* (Participant 4).

This echoes the comment made by another participant about the other members of his/her faculty: *"It's more the subjects are atomistic and I'm responsible for the content knowledge development in my subject and not for all these other global skills"* (participant 2). These comments suggest a number of interpretations: that there is no shared view, that the faculty view is difficult to locate or is invisible, or that there is a noticeable disconnect amongst faculty staff in regard to the role that writing practices have in the curriculum, and the role that faculty staff have in developing students' writing practices.

The emerging picture appears to be of subject coordinators and subjects operating in isolation: *It is probably up to me to take the quality on the subject wherever I want* (Participant 3). While the dedication of the subject coordinators who have participated in this research is not in question, it is to be wondered what engineering students make of these piecemeal practices, and how they learn to write like engineers. At this stage of the analysis it is not clear if all the participants share "the narrow notion of knowledge as curriculum" (Edwards, 2001, p.164), or whether some have a broader interpretation of what the engineering curriculum comprises. If this does emerge, will this reflect their view of writing practices, either to make them more visible, or to see those practices as valuable in themselves?

Participant 5 makes the point that as research supervisors many faculty staff would hope to have research students with high quality writing, as it makes the work of supervision less onerous. Participant 5 is the only participant so far to have a research-only background; the other participants have a range of industry backgrounds. The emphasis placed by this participant on writing tends to relate to the quality of writing in research papers. Yet this participant also acknowledges that students working in industry tend to be better writers than those students who are yet to enter the workplace. All of this builds a picture of absences, of gaps, of practices that are acknowledged to be important but are for the most part acquired in fits and starts,

**Learning to write by osmosis?** One of the most striking findings so far is the limited opportunities for students to practise writing, whether or not it is for an assessment task, and the lack of modelling of writing practices by the subject coordinators. All the participants who have been interviewed so far see writing practices as part of what engineers do, but only one (participant 5) actually shows the students his own writing. It may be that the participants view writing practices in the curriculum as a means of students demonstrating their learning, whereas writing practices in engineering practice are "oriented towards practical or material outcomes" (Freedman & Adam in Russell, 1997, p.231). An alternative possibility is that the participants see writing practices being developed through some kind of apprenticeship model, whether or not they specifically subscribe to theories of situated learning (e.g. Lave & Wenger, 1991). However, situated learning theories do not address situations where novices start tasks that are totally new to them (Blakeslee 1997); furthermore, interventions and scaffolding of tasks need to be explicit for novices to learn or acquire practices effectively. There needs to be: "...accurate diagnosis of the student's current skill level or difficulty and the availability of an intermediate step at the appropriate level of difficulty in carrying out the target activity" (Collins, Brown & Newman in Blakeslee, 1997, p.140). This then requires the master practitioner to have explicit as well as tacit knowledge of how the task is to be carried out. It is possible that the participants in this study (and other engineering academics) lack this explicit knowledge about how writing practices are enacted.

In regard to opportunities for input into assessable writing tasks, strategies vary from very structured subject coordinator feedback (participant 4: preliminary report submitted for feedback) to peer feedback (Participant 3: students are required to submit a draft report which is peer reviewed before the final submission), to leaving it up to the students to seek input: *"In the post-graduate [subject] I have had a number of students who have submitted basically drafts. In the undergraduate [subject] they're more likely to come in and talk to me"* (Participant 1).

On the other hand, the majority of participants initially say they learned writing practices by doing: "picked it up on the job", but then adjust this claim by saying that they followed a model of someone else's work, received feedback from colleagues and/or were mentored by a supervisor (either work or academic).

How did you learn those different practices, those different writings?

*But I think where I really learnt to write reports was during the PhD time. I sat down with the supervisor to write status reports... It's sitting down with my supervisor, side by side, him getting his pencil out, he is the one who taught me how to write (Participant 4)*

*...when I first graduated also I did have a senior engineer there, who if I was uncertain on how to put something down, you'd go and talk to him. So there was a bit of mentoring as well which is the same with the PhD supervisor. It's mainly mentoring than anything (Participant 1)*

*Basically, if I'm writing this kind of paper, I will read at least 20 or 100 papers in that area. I first follow the style. The style is easy to follow and then I write. I write first...*

*Did you - in your PhD when you were studying with your supervisor, did your supervisor give you any advice on your writing?*

*Yeah. He is a very responsible - I learned a lot from him (Participant 5)*

This contrasts with the lack of explicit development of their students' practices. As already mentioned, the majority of participants do not show students their own writing, nor do they necessarily provide an exemplar, nor do they scaffold the writing tasks (with the exception of Participant 4). As can be seen from the above comments, the participants generally acknowledge the role of a mentor or specific instruction in their acquisition of engineering writing practices, but they do not practise this in their own subjects. Whether this is due to large class sizes, the nature of writing tasks that students perform in the early years of their degree compared to the extended writing that they do in the capstone subjects, or a disconnect between the participants' own experience and their teaching practice is yet to be established. Alternatively, there could be a gap between knowing the role of writing practices and making that explicit to the students through the teaching and learning activities in the subject.

In summary, the results so far show that there is often a disparity between what is claimed and what is taught, which indicates that participants have a decontextualized view of writing practices. In addition, there is either a lack of visibility of a developmental approach to writing practices, or significant gaps within the engineering curriculum of the institutions. This brings to mind the title of an article by Charles Bazerman (2003): "What is not institutionally visible does not count", and suggests that the lack of visibility within the curriculum means that writing practices do not count, in comparison to 'technical knowledge'. Furthermore, there are few examples of subject coordinators mentoring or providing hands-on writing practice during classes.

## Conclusions

As this study is ongoing, the conclusions are evolving. What is emerging is that engineering academics who have participated in this study to date seek to develop their students' writing in a number of different ways. However, what is also being revealed is a gap between rhetoric and practice: that the participants do not appear to be using their own writing experiences with their students and that the mentoring role is not present or not very visible. Another element that appears to be lacking is that of feed forward and feedback, so that students may not have the opportunity to develop a contextualised view of their own engineering writing practices and how they can develop within and beyond the engineering



curriculum. One way forward could be that of the mining engineering model, where there appears to be a strong sense of the engineering student developing as a mining engineer, where the writing practices are made explicit and the writing tasks are scaffolded to incorporate feedback and feed forward.

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